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THE STRATEGY FOR INTRODUCING AND OPERATING SYSTEMS OF MAINTENANCE AND REPAIR IN THE DEVELOPING COUNTRIES: -AN INSTITUTIONAL APPROACH-

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THE STRATEGY FOR INTRODUCING AND OPERATING SYSTEMS OF MAINTENANCE AND REPAIR IN THE DEVELOPING COUNTRIES: AN INSTITUTIONAL APPROACH

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CHAPTER I

The nature and classification of maintenance and repair services in the developing countries.

By and large, - most of the developing countries have to import their capital equipments, - plant, machinery, appliances and their spare parts, - from abroad. Almost all of them have low capital bases. Whatever liquid capital they may be able to mobilise, are again not readily convertable into foreign currencies, because of the prevailing trade gaps and unfavourable balance of payment positions.

In spite of such basic handicaps, the industrialisation of developing countries, modernisation of their agriculture and of the public utilities have to proceed. And proceed at a much faster rate than what had taken place in the past, if the widening gaps between them and the developed economies are to be bridged, or at any rate halted. One of the redeeming features in this difficult situation however is, - that in the developed countries, their decision models for maintenance, repair and replacements, are based on high labour costs, - which is not the case in the developing countries. In other words, the high cost of maintenance and repair, often make them discard their equipments and seek replacements rather early, - purely on economic grounds. In the developing countries, where the labour costs are much lower, such equipments could otherwise be conveniently used for substantially longer

periods through added efforts in the way of extra care in maintenance and repairs. This is certainly an advantage for the developing countries, - whose benefit could only be properly realised, by organising satisfactory systems of maintenance and repair, - and trained man-power for operating the same.

In developing suitable organizations and trained manpower for operating such maintenance and repair systems, - though the models of the developed countries could be accepted as broad guides, these could by no means be copied for wholesale adoption, without the requisite additions and alterations, so as to conform to the actual physical needs and economic realities of the developing countries. This calls for a good deal of imagination and improvisation.

Some of the special features of the maintenance and repair services, which stand out rather prominently in most of the developing countries, could be described as follow:-

1. Though the requirements of maintenance and repair services in the developing countries both in quantity as well as in quality are by far greater than the developed countries, - these are yet to take even elementary institutional and organizational roots in the former.
2. Most of the developing countries having been feudal economies in the past are yet to have modern industrial bases and technological skills. The workers, supervisors and managers there do not always have requisite skills

to operate and maintain modern equipments upto the requisite standards of proficiencies, resulting in more frequent breakages, malfunctioning, wear and tear. This calls for extra-efforts towards skill development, both in quality as well as quantity and at all levels.

3. Most of the developing countries are importers of capital equipments. They are unable to keep readily available stocks for replacement as spares in adequate numbers thus causing serious economic losses, through shut downs, and interruptions in production.

4. Many of the developing countries buy their equipments from heterogenous sources in different countries, with different sets of standards and specifications. It is often difficult to provide proper technical facilities and skilled manpower to cater for the maintenance and repair needs of such heterogenous equipments.

5. Most of the developing countries at their present stages of industrial development have rather a limited scale of consumption of industrial equipments and spares. In the absence of the benefits of economics of scale, - it is difficult for the suppliers to provide facilities for major repairs or after sales services. The consumer also cannot always make proper arrangements for major repairs locally, nor undertake indigenous manufacture of spares - which means more dislocation and interruption

in production.

The adverse cost repercussions of all the above factors on the industries of the developing countries could be incredibly high. And these could be substantially reduced by introducing and operating appropriate systems of maintenance and repair, - catering for the actual needs of the developing countries. The additional costs involved in this process would only be a small fraction of the total losses which would have been sustained otherwise through interruption in production and shut downs.

The maintenance and repairs systems cover extensive ranges of activities at an enterprise. These could be classified into many groups and sub-groups depending upon the areas of coverage or types of services provided by them. For the sake of convenience and cogency in presentation, however, these are being divided into the following six broad categories, in terms of the services which could be provided to the different areas of the enterprise:

1. Maintenance of the buildings and grounds
2. Maintenance of the plant equipments
3. Lubrication and inspection of equipments, - including material handling equipments and transport vehicles.
4. Electricity, water, sanitation, ventilation and other utility generation and distribution services.
5. Alterations and additions to the existing plant equipments.
6. Alterations and additions to the existing buildings, grounds, utility generation and distribution services.

In addition to the above categories, certain others related or supporting activities would also fall under maintenance and repair services as follows:

1. Plant protection - fire, sanitation, ventilation general safety and noise control.

2. Store keeping for maintenance work.

3. Management of maintenance and repair workshops and liaison with production departments for manufacture of spares, major overhauls and major repairs as relevant.

4. Waste disposal.

5. Administrative and accounting work.

Depending upon the type and size of the enterprise, it may often be convenient to provide these services for the maintenance work from within the existing organisational arrangements of the enterprise operations. For example, maintenance stores could be looked after by the normal storekeeping organisation. Similarly the engineering departments could also be used for plant protection, production of spares, major overhauls, waste disposal etc.

Apart from the above classifications of the maintenance and repair activities based on the types of services provided to the different areas of the enterprise operations, - these could also be viewed from their functional aspects, in the context of time available for systematic planning, scheduling and executing such activities as follows:

1. Preventive Maintenance

This stands for regular inspection of plant and equipments

at stimulated intervals, to detect the adverse operating conditions, structural or functional deteriorations, which might lead to their breakdowns, damages or excessive depreciations, with a view to take timely remedial measures to lubricate, adjust, repair or take such other appropriate steps which prevent losses to the enterprise. Preventive maintenance involves observance of systematic maintenance routines by the operatives, as well as by the servicing departments. In some of the enterprises, preventive maintenance is used in rather a narrow sense, confining the activities to inspection, lubrication, adjustments and testing - informing the user departments defects noticed by them which required repair, replacement, overhaul, modifications etc., to be followed up by them. This is done with a view to conform to the time schedule of preventive maintenance. In the light of the experiences in the developing countries, in certain situations, it is often desirable to involve the maintenance departments with the direction and inspection of such repair, replacement, overhaul and modifications. This does not mean that the user departments are absolved of the basic responsibilities, for ensuring that preventive maintenance of their equipments are carried out systematically and satisfactorily, but to ensure that the maintenance department has a complete picture for discharging its service obligation to the users. This topic however will be elaborated at greater lengths in Chapter IV

when discussing the strategy of operations.

2. Operational Maintenance

In a running factory interruption in production may take place due to accidents, breakdown of equipments, power supply, gas, water, conveyors etc., for which operational maintenance staff are provided, to set the defects right for resumption of production work. Some of the operational maintenance staff are required to function round the clock even though factory may be working on one or two shift basis. Operational maintenance is mostly inter-linked with break-down repairs - a point which has been further elaborated in Chapter IV later on.

3. Repair

From a broader perspective repairs services are really parts of maintenance services. From a narrower point of view, the necessity for the upkeep of proper systems of repair basically emanate from three different sources:-

(a) Preventive Repairs

In a number of cases, - particularly in the developing countries, actual breakdown of plant equipments are often the cumulative results of several minor breakages, damages, distortions and maladjustments. Whereas most adjustments could be rectified on the spot, breakages, damages and distortions may require timely repairs or replacements, if more serious shutdowns or breakdowns are to be avoided. Proper systems of preventive maintenance therefore have to be complemented by preventive repairs in those cases where wholesale replacement might not be necessary. This

aspect gains added importance in the material scarce economies of the developing countries. Minor repairs or adjustments could be carried out, by technical staff engaged in preventive maintenance on the spot, but where this would upset the time schedule for preventive maintenance, these should be undertaken separately.

(b) Breakdown Repairs

Break-down repairs on an emergency footing, are required to be undertaken, when the equipments have actually failed, causing interruption in the factory work or in the factory services. Like minor preventive repairs which are executed by the preventive maintenance departments, minor break down repairs could also be attended to operational maintenance staff. When this is not practicable the defective part is replaced - by a good one sending the former to factory for repair, if repairable, or scapping it altogether if not. When spares for replacements are not available as often happens in many factories in the developing countries, emergency repairs on top priority may have to be undertaken, to reduce the period of interruption in factory operations.

4. Alterations and Additions

These emanate from periodical reviews, designed to bring about the necessary improvements in the operation of the plant

equipments, buildings, sanitation, utility generation and distributions etc., so as to ensure uninterrupted flow of work. Where existing equipments and facilities are manifestly defective, or which persistently fails, efforts are made to alter these or add to these with a view to bring about the necessary improvements.

CHAPTER II

The Institutional Arrangements

The institutional arrangements for preventive maintenance and repair services could be organised at four different levels i.e., (1) National level (2) Industry levels (3) Regional levels (4) Enterprise levels.

1. National level

The fact that the resource scarce economies of the developing countries, with lower labour costs should give added importance to maintenance and repair services had been stressed earlier. But in actual practice, this is seldom the case. Not only adequate facilities for operating these services in the developing countries are not available, the extent of harm which such a state of affair is doing to the interests of these countries is seldom realised by them. In other words, there is a conspicuous inadequacy of consciousness on the urgency as well as the importance of the problem in the developing countries. The primary objective of making institutional arrangements at the national level therefore is to generate a satisfactory level of repair and maintenance consciousness, through the length and breadth of the country, amongst the corporate bodies, the management and the engineering personnel at different enterprises, public utilities - in fact at all establishments wherever sizable technical operations are undertaken.

The task of generating such a widespread consciousness becomes most effective, when the cost implications of maintaining such services in terms of anticipated gains through cost reduction and better output, -

both in quantity as well as in quality are explained in clear terms to the business managers, engineers and the financial administrators through proper publicity materials. To make this proposition clearer, it is desirable to explain the situation in terms of the productivity of the capital deployed for organising and operating maintenance and repair services. In order to be really effective, publicity materials on techno-managerial themes have to be expressed in the simplest possible language supported by adequate number of illustrations.

Apart from preparation of publicity material, the national institution could also undertake data collection and research through work sampling, could organise short seminars explaining the benefits and the methodologies of operating such services among the top-managers, to begin with, stimulating discussions and their active involvements in the process. Once the topics get some foothold among the top managers, systematic follow up actions for ensuring the spread of the relevant ideas among the middle managers, supervisors and workers could be initiated at the national level. But such efforts towards the spread of the ideas, and what is even more important, the practical methodologies in organising and operating maintenance and repair services at different enterprises, need the co-operation and co-ordination with more specialised institutions and local organisations as elaborated below. The national institution has a basic responsibility in promoting such institutions and organisations throughout the country if maintenance and repair services are to be really effective vehicles for raising the level of productivity of the developing countries.

Apart from generating the satisfactory level of consciousness and other services mentioned above, - the national institution could also provide information on latest developments in such fields, by maintaining contacts with similar organisations in the developed and developing countries. It could promote study-missions and exchange of experience with different countries seeking to strengthen their maintenance and repair services. It could provide publicity literature, audio-visual aids, to different institutions and organisations interested in propagating the subject, - and where circumstances permit, it could promote symposia and discussions for exchange of technical and methodological knowledge and experience within the country.

2. Industry-levels

Notwithstanding the basic role of the national institutions in promoting maintenance and repair services, it will be readily recognised that such services have considerable amount of variations in their organisational structures and operational procedures for different lines of production. For example, the sort of maintenance and repair which are required in a steel mill will be substantially different from the maintenance and repair required in factories engaged in manufacturing transistor radios, shoes, or optical instruments.

Since the production processes in different factories in a country are far too numerous for each one of these to have its own

corporate body for supporting maintenance, and repair activities, - it will be convenient to classify all such production processes cogently under appropriate generic heads, for the purpose of such industry-wise institutional support. Classifications of this nature for different countries, will naturally assume different forms, so as to cater for their own peculiarities viz., the type of industries, and state of industrial development, resources, climatic conditions etc. For example in a medium-sized country, it may be necessary to have industry-wise institutional arrangement on a fairly broad foundation - i.e., Chemical Industries providing coverage to refineries and petrochemicals, pharmaceuticals, fertilisers, rubber and plastics - all functioning under the same roof. In a bigger country provision for such institutional support could be diversified and specialised for providing coverage to different areas.

In view of the special importance of the repair and maintenance services in the developing countries, one might think of having an exclusive institution restricting its coverage to maintenance and repair services only. But in practice, this is neither desirable nor practicable. Successful operation of maintenance and repair services, involve intimate knowledge and relationship of such activities with those of other departments of the enterprise, particularly production and engineering departments. The technological bases in most of the developing countries are much weaker as compared to the developing countries. The problems of operating such services can seldom be successfully solved when dealt with in isolation from other

activities of the engineering and production departments. In the circumstances, rather than setting up institutions to provide exclusive coverage to maintenance and repair services for certain groups of industries, - by far the most effective solution will be to set up maintenance and repair cells in the professional engineering institutions functioning in major technical lines, i.e., Institution of Metallurgy, Institutions of Chemical, Electrical, Civil, Electronic, Ceramic or Aeronautical Engineering. Each one of these could promote a specialised cell within their existing organisational and technical set up to provide specialised coverage to maintenance and repair aspects relevant to the lines.

As distinct from the general coverage provided by the national institution, the types of services provided by such institutions are much more elaborate and specific in character. These professional institutions could conveniently organise short term training courses for the middle managers, supervisors and technicians on maintenance and repair activities in their own lines. They could also give a hand in publishing manuals and guides for such personnel on maintenance and repair work in their respective lines, and at a reasonable price.

Apart from training activities, - such specialised institutions could also become repository of more detailed knowledge and information in different lines, in terms of contemporary developments taking place elsewhere. After developing a satisfactory degree of expertise in different production lines, - such institutions could also undertake

consultancy assignments, — which will not only provide a testing ground in the actual field of such information and knowledge, but will also provide valuable feed back and research material for the national organisation and to others interested in the same.

3. Regional level

Both the national as well as industry-wise institutional support for operating repair and maintenance services have pronounced promotional bias. But support at the regional level has a service bias and is primarily intended to provide such maintenance and repair services which are normally beyond the capabilities of individual enterprises on payment of prescribed fees. Thus such regional maintenance and repair establishments are run on a commercial basis, but has to be promoted as a calculated measure, with a social purpose in view. This aspect is particularly important for small and medium scale industries, which do not always possess the requisite technical competence to cope with all their maintenance and repair problems. As mentioned earlier, in the developing countries, suppliers of plants and equipments do not often maintain their aftersale service, and workshops for major overhaul and repair, nor is it always practicable to send the equipments abroad for such servicing, overhaul and repair. This means, that in the developing countries, major overhaul and repairs, beyond the technical capabilities of the enterprise, must be attended to within the country, and at not too distant a place, if serious interruption to production is to be avoided. This is precisely the justification of providing highly developed professional services to undertake

maintenance and repair contracts for the different enterprises in different regions of the country. Owing to a fairly common tendency for the industries in different lines, to get localised in different areas in the country, it is desirable and convenient to operate such regional servicing institute to specialise in maintenance and repair work on one or two major lines of production i.e., textiles, foundry etc. Indeed, when this is the case, suppliers of plants and equipments who sell these under a guarantee may find it convenient to appoint them as their authorised repairers. Many other manufacturers may be quite happy to supply the necessary technical information on maintenance and repair to retain the good name of their products in the market..

4. Enterprise level

Enterprise level maintenance and repair services in the developing countries must not only receive the normal care and attention as is in vogue in the developed countries, - but a lot more, - in view of the added cost repercussions as elaborated earlier. In practice however, maintenance and repair service in the developing countries are often dealt with in a perfunctory manner, - with a overwhelming preponderance of break-down repair carried out by the production and the engineering departments, without any systematic planning, implementation, or up keep of records. Irrespective of whether it is the testing of the lifting appliances, servicing of the conveyors, checking of the gauges, or maintenance of the blast furnaces and kilns, it is necessary to drive home at all levels of

the enterprise as to the extent of losses it would suffer because of these - how the safety, health and smooth functioning at the enterprise would be affected if these are not carried out properly. Apart from educating and training the managers, supervisors, and workers on these services through lecture, demonstration, film shows, - the co-operation of the workers organisations should also be sought in this regard. These aspects however have been elaborated further in Chapter IV, and for the present, it will be sufficient to stress that maintenance and repair services at the enterprises need special attention and care in planning, organization and implementation covering all engineering including store preservation activities at an enterprise.

CHAPTER XII

The Strategy of Introduction

Whenever introducing a new techno-managerial theme, naturally the basic strategy to be adopted towards this should be to convince those in commanding positions who are primarily responsible to implement the ideas. Such a process of implementation of new ideas is made a lot easier, if there is a basic appreciation and acceptance of the themes among those directly involved below the top-management i.e. the middle managers, the supervisors and the workers, and of course the all important trade union leaders.

Maintenance and repair services, are however not new themes. These have been known and practised in almost all human societies in some form or the other and from the remotest days of antiquity. What is new in these however is a proper scientific approach, - both in planning and organisation, as well as in terms of rapidly advancing technologies. This paper however is not concerned with the technological aspect of maintenance and repair services, but with the popularisation and extension of such services at engineering and manufacturing establishments on a proper scientific basis.

In most of the developing countries however, enough published materials are already available on maintenance and repair services. Yet these are not catching up. The implementation of the relevant ideas are inadequate, particularly in the context of their basic economic and operational importance to the developing countries. Amidst such a sluggish and tardy operation of the maintenance

and repair services, - some sort of shock treatment which will make people "wake up" - is often necessary. Social psychologist tell us that such a shock treatment for awakening a mass consciousness, can be best done in terms of three basic emotions i.e., pleasure, grief or indignation. Of these three, the one last named i.e., indignation could be used very successfully to awaken consciousness on the importance of maintenance and repair services, when acceptance of the ideas and their implementation are sluggish and tardy.

This could be best done, with a degree of dramatisation to generate some popular sensation from the top political levels, - i.e., by the Finance Minister, Industries Minister, or even the leader of the opposition, - by publicly accusing that the country is losing so many million rupees, pounds or dollars every year, because of indifference and neglect to operate proper systems of maintenance and repair. Pecuniary data for this could be broadly mobilised through work sampling and scrutiny of past records on interruptions and stoppages of work and the cost figures appertaining to these from a few representative institutions.

Before such a popular sensation is created, a good deal of preparatory work is involved to plan and organise "What next?" - Popular indignation when excited is rather a hungry phenomenon, - and wants its food. By all means provide food for it - upto a limited extent but well below the point of satiety. Fill up the rest with fuel - so that such indignation keeps on burning. All these require careful and advance planning.

When the political V.I.P. creates a public sensation, by his

indignant statement about the losses which the country is suffering, through neglect and carelessness in the field of maintenance and repair, he must also have, - at least a broad outline of the solutions which will mitigate the problem, followed by an exhortation, to set up a national organisation of managers, engineers and scientists who shall provide the country with the necessary leadership and guidance in the field of maintenance and repair services. He must clearly mention about the governments anxiety to promote such services on a country-wide basis, and announce a grant for setting up a national institution or at least for adding a new department to an existing national institution in the field of engineering or management, for providing coverage to repair and maintenance services. He may also like to make two additional announcements, the first one on convening a national conference or a seminar of top technocrats for organising industry-wise, regional and enterprise level maintenance and repair services, and second one declaring a few national awards annually for contributions towards the arts and the sciences of maintenance and repair by the engineers and the scientists, by the managers and by the workers.

In convening the national conference, it must be ensured that the participants represent different industries, different geographical areas where sizable engineering and manufacturing works are carried out or are to be carried out, different professional interests, i.e., managers, scientists, engineers and their professional institutions, trade unions, manufacturer or importers of capital goods and spare

parts etc. Such a national conference must come up with specific plans and recommendations for setting up industry-wise, regional and enterprise level organisations, and also set up sub-committees to follow these up systematically, reporting results to the national organisation at periodic intervals. It will be a valuable contribution to the cause of maintenance and repair services, if this conference agree to publish a quarterly if not a monthly journal on repair and maintenance services under the auspices of the national organisation which would disseminate relevant information, at home and abroad, publish important contributions by the technocrats on the subject, and report progress on the various aspects of the movement, at the national, industry-wise, regional and enterprise levels.

The fact that governmental patronage to the maintenance and repair services is provided or that a limited amount of public funds are deployed for this purpose should not be construed to mean that responsibility in introducing and operating such services rests with the governments. In fact nothing is further away from truth than this. By and large, most of the developing countries are emerging from feudal traditions, with shaky industrial bases, traditions and resources. Few of them have such corporate organisations of technocrats, which could stand on their own feet without governmental patronage. Governmental patronage towards maintenance and repair services are therefore not only necessary, but also desirable to ensure smooth functioning and broad acceptance of themes at different levels of the nation's economy. But the techno-managerial

organisations and their activities in a country must necessarily be such which are planned and operated through the corporate efforts of technocrats, enterprises, and institutions, if these are to make the desired impacts. In other words, governmental patronage could be compared to a decorative and protective garment for the corporate bodies of technical and professional people, engaged in introducing and operating maintenance and repair services in the country and on an extensive front.

CHAPTER IV

The Strategy of Operation

After the modern maintenance and repair services had been introduced to the enterprises and engineering establishments through the activities mentioned earlier, these have to be organised for physical operation - at least in a few model plants on a selective basis to start with. In applying the principle of selectivity in the process of organising and operating such services, the basic objective would be to generate the requisite multiplier effects. While selecting suitable firms for generation of multiplier effects in this field, following factors should be kept in the forefront.

1. The firm must have progressive managers and should enjoy public esteem for their techno-managerial excellence.
2. The firm has a high turnover, and there should be good scope of demonstrating the effectiveness of maintenance and repair systems in pecuniary terms which could impress and inspire others.
3. The firm should be in a major line of production in the country, so that its example and experience could be readily followed by other firms engaged in similar lines of production.

Systematic operation of maintenance and repair services in a few firms having the above characteristics, results in emulation of their examples and spread of such services to other firms quite rapidly. On the top of this, - a competitive spirit is also set into motion amongst the enterprises so as to excel one-another in this direction. If the managers of such firms are also members of one or more of the institutions mentioned in Chapter II, - then soon enough the situation warms up and a favourable climate is created for further spread and improvement of the maintenance and repair services.

There is another important aspect of the principle of selectivity which assumes special importance, particularly at the initial stages, when additional resources for operating maintenance and repair services, inclusive of trained manpower are rather meagre. This refers to selecting more important areas of plant operation for intensifying the quality and the quantity of maintenance and repair services, giving less importance to other areas. The underlying principle for operating selectivity in this field is higher the cost implication of breakdowns, - greater is the attention required. In considering this aspect it might be worthwhile to ask the following questions:

1. Is this a critical item? If failure will cause a major shut down, or costly damage, or harm to an employee, need for proper maintenance is almost certain.

2. Is standby equipment available in case of failure? One can often rent air compressors or package boilers on short notice. If the load or duty can be easily shifted to other equipment, need for proper maintenance is contingent on other factors, such as cost of "breakdown" maintenance.

3. Does cost of proper maintenance exceed expense of downtime and cost of repair or replacement? If it costs no less to tear down a machine to repair a repetitive wear point than the over-all cost of the repair itself, the value of proper maintenance is questionable.

4. Does the normal life of the equipment without maintenance exceed manufacturing needs? If obsolescence is expected sooner than decay, maintenance may be a waste of money.

In the context of the information elicited from the above scrutiny, - the maintenance and repair work covering the entire plant could be divided into four categories, carrying out what may be popularly called a VEIN Analysis

(V = Vital, E = Essential, I = Important, N = Normal)

(a) Vital Areas:

Areas where any breakdown would result in very costly repairs or replacement and almost a complete closure of the plant operation, for which no standby facilities are available, resulting cessation of production work for a considerable period of time. The example of this is a cupola in a foundry or a turbine in a thermal plant, for which local repair facilities might not be available.

(b) Essential Areas

Areas where any breakdown would result in expensive repairs and replacements and cessation of work in a major area of the plant operations, for which no standby facilities are available, resulting

in serious interruption in production for a substantial period. Example of this could be found in the failure of the main power unit in a conveyor system or failure of a major heat treatment furnace used for softening forged materials before machining in the direct line of production.

(c) Important Areas

This refers to major areas of enterprise operation, for which though standby or local repair facilities might be available, - would nevertheless involve substantial expenditure in repairs or replacement and serious interruption in production work.

(d) Normal Areas

Normal areas of maintenance operation are those where a breakdown will entail nominal expenditure in repair or replacement or minor interruption or delays in plant operation.

The VEIN analysis mentioned above operates around the direct cost implications of repair or replacements, as well as indirect cost implications emanating from interruptions in plant operation. In developing model for classifying the maintenance and repair services in terms of direct and indirect cost implications into four categories as mentioned above, a broad analytical estimate is all that is needed to startwith. Such an analytical estimate would no doubt vary depending on the nature of the enterprise, and the facilities, particularly stores and repair facilities that could be mobilised both within and outside the enterprise.

Apart from applying the principle of selectivity in the above contexts, the strategy of operation of the maintenance and repair services within an enterprise is also vitally concerned with organisational arrangements and the costs for operating the same, - a- ing due regard to efficiency and progressive improvement in such services over a period of time. In operating maintenance and repair services, ultimately it is the economic consideration that is the basic deciding factor, and a purely engineering approach might lead one astray. It may be possible to eliminate breakdowns even of ordinary items from engineering point of view, but it may not often be worthwhile to do so from the economic point of view as it is futile to spend pounds to save the pennies. It is however relevant to reiterate here that the method of categorisation of maintenance and repair work in terms of economic considerations must be developing country's own - and cannot be copied even from similar factories of the Western countries, where labour costs are high and replacement costs often cheaper.

Whereas repair work irrespective of whether it is preventive r- air or breakdown repair must necessarily be carried out with appropriate priorities whenever replacement is not called for on economic grounds, it may not be practicable to cater for the requirements of preventive maintenance covering the whole establishment all at once. The VEIN analysis elaborated above, operates the principle of selectivity on economic consideration, and not on physical or functional divisions of the enterprise. The question

which automatically arises at this point is how and on what organisational arrangements one is to get on with the job to start with. Along with this, one also has to consider as to how much of the maintenance work could be carried out by the shop managers, or supervisors of different work centres.

Normally the maintenance work at an industrial enterprise - would by and large cover the following areas:-

1. Process equipment — furnaces, heat exchangers, piping, pumps, compressors, motors, stills, instruments.

2. Safety equipment — vacuum and pressure-relief valves, flashback or flame arrestors, breathing and emergency-relief equipment.

3. Utility equipment — main boilers, electric generators, supply, storage, and distribution systems for water, steam, and compressed-air pipelines.

4. Tanks and auxiliary equipment — storage tanks, pipelines, dikes, drains, gages, and measuring instruments.

5. Plant buildings — includes shipping and storage areas, also transportation equipment such as tank cars and transfer pumps.

6. Fire-protection equipment — water supply and pipelines, pumps, permanent fire-extinguishing installations of foam, fog, gas, spray, or dry powder, first-aid extinguishers, fire trucks, alarm systems.

But during the early stages, when maintenance staff are still being mobilised and trained for the job - it will be desirable to entrust "Vital" and "Essential" items from the above lists to the centralised maintenance organisation, delegating the responsibility for the maintenance of "Important" and "Normal" items to the shops.

In apportioning such responsibilities, however, the technical and economic prudence of the maintenance departments as well as the shops would be supreme, so as to ensure cogency and ease in operations rather than adhering to any rigid formula. As more and more experiences are gained, the pattern of division of responsibilities, could be rationalised further.

The VEIN analysis indicated earlier classifies maintenance work in terms of economic repercussions. This would lead to the question of reducing losses by adjusting the frequency and depth of inspection for maintenance, - which is a technical question requiring systematic engineering analysis on the following lines:-

1. Age, condition, and value. Older and poorer equipment needs more frequent services. But if ready for the junkpile, or soon to be obsolete, may be cheaper to inspect on a skeleton basis or not at all.

2. Severity of service. More severe applications of identical equipment require shorter cycles. In a process plant you might need to inspect a critical pump every day - the same type of pump in a metal-working plant only once a month.

3. Safety requirements. Allow a wide margin for safety. For example, one plant inspects the solenoids operating the clutches on presses every 2 weeks.

4. Hours of operation. Many manufacturers suggest frequency cycles based on an 8-hr day, others on usage (such as mileage). Buildings and seasonal services operate on a calendar basis. Sometimes two bases are used, whichever comes first. For example, sump cleaning may be needed when changing operations, or at least every 30 days.

5. Susceptibility to wear. What is exposure to dirt, friction, fatigue, stress, corrosion? What is life expectancy?

6. Susceptibility to damage. Is it subject to vibration, overloading, abuse?

7. Susceptibility to losing adjustment. How will maladjustment or misalignment affect it? Where manufacturing tolerances are tight, shorter inspection cycle is needed.

Such an engineering analysis however throws up the basic issues in the process of decision making. In the developing countries, experience has proved that many of the items which manufacturer would suggest replacement after a certain defect had appeared, are eminently suitable for repair. A critical technical examination of the possibilities of satisfactory repair, (even though a manufacturer who is often too anxious to sell extra spare parts might recommend far too early replacements) could be a source of considerable economy to an enterprise.

As far as repair services are concerned, apart from breakdown repairs, for the purpose of administration and organisation, it is convenient to include preventive and upkeep repairs under this, irrespective of whether the work involved is derusting of pipes, painting of buildings, welding, or electro-deposition of metals on worn out parts. One of the reason why in the developed countries simple repair works are often not undertaken by the maintenance staff, even when this is well within their technical competence, is that the latter have to work on highly organised and tight time schedule. It will not be possible for them to adhere to the pre-determined maintenance schedule if they were to undertake even simple routine repair works. This is however not the case, in most of the developing countries, particularly

at the initial stages, when the maintenance programmes have considerable amount of flexibility. In all such matters, what is most important is to keep alive a spirit of service, particularly among the supervisors of the maintenance teams. It should be impressed upon all maintenance operatives that shop managers are their clients and maintenance staff should go to the farthest extent to satisfy them, soliciting their goodwill and co-operation in the process.

As regards basic additions and alterations to the existing plant facilities, normally these should be specially scheduled and accounted for. But when the nature of work involved is such that these could be undertaken without much dislocation of normal work, then on economic consideration these may well be undertaken by the maintenance and repair departments. Before accepting any such additional responsibility, the precise technical and economic implications of this must be made clear to the top management.

There are two other basic issues concerning the repair services which deserve special consideration. The first one amongst these relate to the organizational arrangements for executing repair work and the second one concerns priority administration. It has been envisaged earlier that routine and simple repair works could be undertaken by the maintenance staff for which a special maintenance workshop could be provided. Apart from the special facilities which a particular enterprise might require, following equipments by and large would cater for the general requirements of an average

Maintenance workshop:-

1. General Purpose Lathe
2. Drilling Machine
3. Shaper
4. Planer
5. Double Ended Grinder
6. Tool Post Grinder
7. Forge and Smithy equipments.
8. Heat treatment furnace, cyanide bath and quenching tank.
9. Gas and Electric Welding.
10. Hand and Power hacksaw
11. Abrasive Cut-Off wheels
12. Assorted hand tools and measuring instruments.

The advantage of having such a workshop under the maintenance department would be expeditious clearance of work depending upon urgency of the situation, without seeking extra-departmental assistance. Naturally workshop of this nature will not be able to carry out major repairs. For this purpose, assistance of regular engineering departments and when such repairs are beyond the technical competence of such departments, - outside assistance may have to be sought. This means that the supervisors in the maintenance shops should be familiar with the technical capabilities of the enterprise, as well as of those outside workshops, which might be located in the vicinity. Irrespective of whether major repair and overhauls are undertaken by the enterprise or placed on a outside shop, - an effective pattern of priority administration for executing break-down and maintenance repair work has to be developed under the authority of the top management.

It will be appreciated that operation of satisfactory systems

of maintenance and repair are matured and built up over several years even in the developed countries. The published literature and guide-lines on these are at once vast and complex. In the above paragraphs attempts have been made only to highlight some of the major areas which are of specific importance to the developing countries. Managers and engineers desirous of having further information on the subject should consult the bibliography listed at the end of this paper, paying particular attention to modify these to conform to the physical, technical and economic realities in and around their enterprises.

CHAPTER V

Cost calculations and Evaluation

Cost calculation constitute an essential part for introducing, operating and evaluating maintenance and repair services. Unless the extent of loss which a developing country might be suffering is expressed in pecuniary terms, it seldom produces the degree of seriousness for effective and widespread introduction of such services. Unless economics of the different aspects and areas of such services are properly comprehended, it is difficult to operate such services on scientific lines. Unless pecuniary parameters are used, it is difficult to evaluate the effectiveness of such services. It will be seen therefore that without a reasonably satisfactory method of cost calculations, effectiveness of maintenance and repair services would be seriously handicapped.

In spite of its basic importance, - cost calculations operating amidst so many variables, - some of which are little more than broad approximations if not speculations, can hardly expect to attain that degree of perfection which are normally expected by the accounting profession. Yet this limitation has to be accepted and attempts made to make the best of a difficult situation, particularly during the initial stages.

As far as the direct costs of maintenance and repair are concerned, these are comparatively easy to compile, based on historical costs and could be estimated on fairly sound bases. But the indirect costs on shutdowns or interruptions are likely to suffer wide variations unless

adequately supervised at professional levels. In any case the broad cost estimates prepared for operating VEIN analysis as indicated in Chapter IV could be accepted as bases. In doing so the best answer usually is to translate the loss of production in terms of manufacturing costs, added by proportional overhead costs.

In most factories in the developing countries, records of time lost for routine breakdown repairs may not be available. But as the spread over of such events are fairly big, - these could be computed statistically through work sampling. As regards major breakdowns or interruption in production, perhaps records may well be available, and in such cases these should be computed in terms of money values as suggested earlier. If these are not available, then major breakdowns being important events, and since workers and supervisors should know their frequency and extent, necessary information could be extracted from these for computing the pecuniary figures. This would mean reliance on verbal statements, - but this is the best which could be done in the absence of more precise information. The importance of proper upkeep of necessary records for cost calculation however has to be stressed on the management, and perhaps, from that time onward cost calculations would become easier and more accurate propositions.

As regards evaluation of the benefits of the maintenance and repair services, this is best done in terms of productivity of additional capital deployed. As it is well known productivity is the relationship of the output over the input i.e.,

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Productivity of the money spent on operating the maintenance and repair services would be

$$\text{Productivity of additional capital deployed for maintenance and repair} = \frac{\text{Economic gains}}{\text{Additional costs for maintenance and repair.}}$$

As regards the economic gains generated through strengthening the maintenance and repair services, these could be computed in terms of reduction in interruption in production, reduction in repair and replacements, inclusive of proportional addition of overheads to the figures. It is not necessary to add such proportional overheads to the additional costs for maintenance and repair, - as the latter is a precise figure of actual incremental cost incurred, which would include elements of overhead if any that had been spent in the process.

For the purpose of a reasonably satisfactory and broad cost calculation and evaluation, the methods indicated above could be generally accepted. If however further refinements are required in any particular direction, then these could be easily constructed, more or less, on the very same foundations.

Acknowledgement

In compiling the material for Chapter IV, the author has at a few places followed the pattern of the check list prepared by Mr. Carl G. Wyder on Preventive Maintenance published in Maintenance Engineering Hand Book.

BIBLIOGRAPHY

Clapp and Poliak Inc: "Techniques of Plant Maintenance and Engineering"
New York, 1954.

Cooling W.C. "Maintenance Incentives are Practical - But"
"Factory Management and Maintenance"
New York, February, 1954.

Morrow L.C. "Maintenance Engineering Hand Book"

Ministry of Labour (U.K.) "Plant and Machinery Maintenance"
H.M.S.O., London.

Cooling W.C. "Small Plant Maintenance Control"

Lavis Bernard and Peason William C. "Management Guide for Maintenance and Cost Reduction"
John F. Rider Publishers Inc., New York.

Long A.F.De "13 ways to uptodate your Preventive Maintenance"
Factory Management and Maintenance
Vol. 113, No.2 Feb. 1961.

Robinson A.M. "Planned Repair Jobs Hand Down Costs"
Factory Management and Maintenance Vol.119
No.7 July 1961.

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